Chapter 13. Zion National Park

Introduction

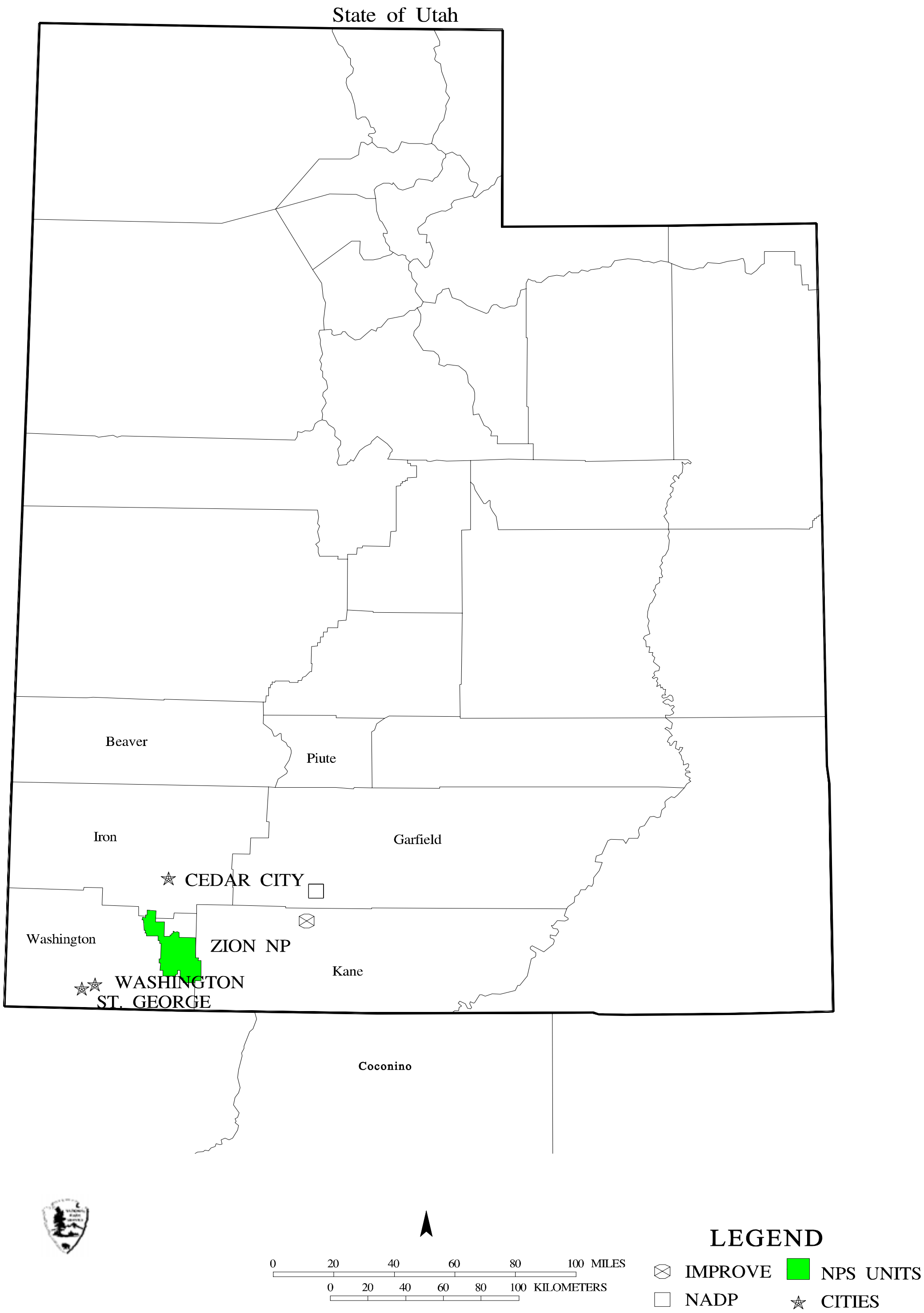
Zion National Park was established as Mukuntuweap National Monument in 1909 and then expanded and renamed as Zion National Monument in 1918 . Zion became a National Park in 1919. The purpose stated in the enabling legislation was to protect an extraordinary example of canyon erosion and features of unusual archeological, geological and geographic interest for scientific research, the enjoyment and enlightenment of the public, and visitor enjoyment of its grandeur and scenic features.

After a series of boundary changes, Zion National Park now encompasses 59,327 ha in the southwestern corner of Utah, of which 57,887 ha are federal. Zion National Park is on the far western edge of the Colorado Plateau and includes the southern and western perimeter of the Kolob Terrace which is a southern extension of the Markagunt Plateau (Figure 13-1). Zion Canyon is the main canyon in the Park and is the product of down-cutting of the Virgin River. This cutting has resulted in outstanding exposures of Triassic and Jurassic age deposits including 600 m thick sections of Navajo Sandstone. These exposures, along with the Kolob finger canyons to the north, and examples of quaternary volcanism to the west, are the main geological features of interest in the Park. Elevations range from 1117 m where the Virgin River leaves the Park to 2664 m at Horse Ranch Mountain in northern end of Zion. Many archeological sites are found in Zion. Most of the Park lies within Washington County, with a small eastern portion in Kane County and a small northern portion in Iron County. About 60% of Zion is bordered by BLM land, and the rest by private land.

Geology and Soils

Most of the geology of Zion National Park begins in the Mesozoic era during the Triassic period, with only a small northwest tip of the park dating from the older Permian period. The Triassic was a dynamic time with climates that spanned equatorial wet climates to sub-tropical desert climates. During the 40 million years of the Triassic, tremendously varying depositional environments produced diverse strata, from the early Triassic silt and clay deposits of the dark red Moenkopi Formation to the mid-Triassic gravelly sandy Shinarump Conglomerate to the late Triassic, gray-blue

Figure 13-1. Location of Zion National Park.



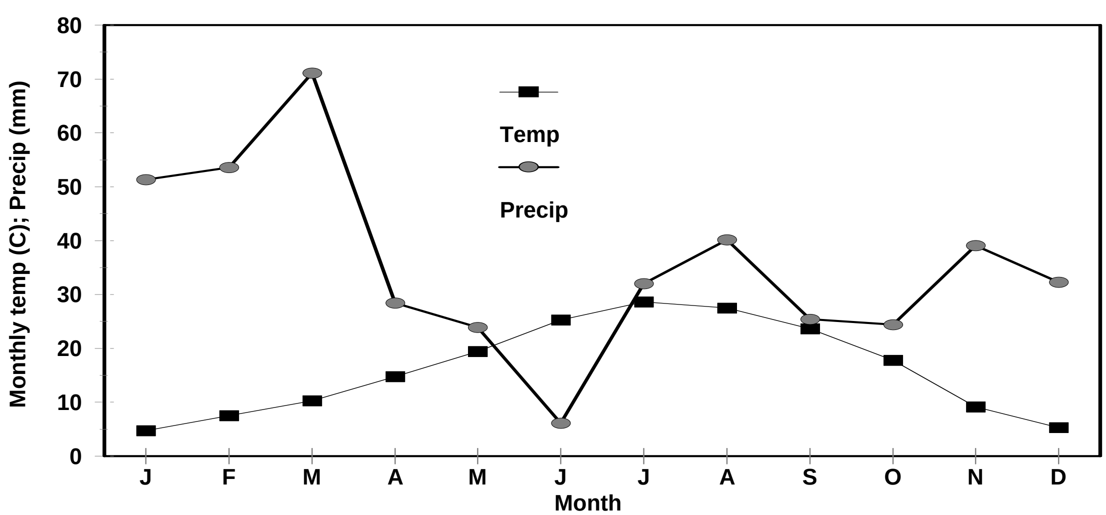
Map produced by the National Park Service Air Resources Division 12/19/96

Sources: USGS 1:2,000,000 cdrom and NPS ARD GIS

Chinle Formation formed from fine grained material derived from volcanoes. The entire region became a large desert of sand by the end of the Triassic and through the Jurassic; the sand dunes became the massive tan and red Navajo Sandstone. Seas advanced again at the end of the Jurassic, depositing the “cap” formations of Temple Cap Siltstone, topped by desert sand deposits of Carmel Sandstones. The youngest sedimentary layer in Zion is the Dakota Sandstone, a beach deposit at the edge of a Cretaceous sea. Near the end of the Cretaceous, the mountains to the east rose, forming the Rockies, and prevented any further incursions by seas. The subsequent Cenozoic Era has been a time of erosion in Zion National Park, including the down cutting through Mesozoic Era sediments by the Virgin River (Chronic 1988).

Climate

The semi-arid climate of southwestern Utah is modified by Zion National Park’s intense topography and large elevation gradients. The higher elevation sites in the park are cooler and wetter while the opposite holds for lower elevation sites. At the park’s headquarters near Springdale, average daytime highs range from 11 ^{O}C in January to 37 ^{O}C in July, while night-time temperatures for these months average -2 ^{O}C and 20 ^{O}C (Figure 13-2). Most of the 370 mm of average annual precipitation falls as rain and snow from November to March, with a summer monsoon peak in July and August. June is particularly dry.



Vegetation

Seven major vegetation types occur in Zion National Park (Harper 1994). Pinyon (*Pinus edulis*) / juniper (*Juniperus scopulorum*) is the most widespread community, covering over 46% of the Park. Rock Crevice communities and Great Basin Mountain shrubland communities, each cover about 13% of the Park, including some pinyon and juniper, Gambel oak (*Quercus gambelii*), serviceberry (*Amelanchier alnifolia*), ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), bigtooth maple (*Acer grandidentatum*) sagebrush (*Artemisia* spp.), and blackbrush *(Coleogyne ramosissima*). The ponderosa pine community type occurs over about 8% of the Park, and a mixed conifer community type dominated by Douglas-fir and white fir (*Abies concolor*) covers 6%. The remaining 14% of the Park is covered by barren rock, very arid Great Basin desert blackbrush and sagebrush shrublands, disturbed desert grasslands, and warm temperate riparian forests (with Fremont cottonwood (*Populus fremontii*)). A complete listing of plant species for Zion is provided by NPFlora while lichen lists for Zion are provided by Nash and Sigal (1981), NPLichen, and Rushforth et al. (1982). No information is available on threatened, endangered or rare plant species for Zion National Park.

Madany and West (1983) tried to gauge the legacy of cattle grazing within the Park by comparing vegetation on previously grazed Horse Pasture Plateau with ungrazed Church Mesa and Greatheart Mesa. These areas are dominated by ponderosa pine, and the ungrazed locations had higher densities of pine, oak and juniper saplings, and greater cover of grass and forb species. The authors attribute the differences in vegetation among these areas to grazing. The formerly grazed site had a much higher fire frequency (average return interval of 4 to 7 yr) prior to initiation of grazing in the 1880s than the ungrazed mesa (average return interval of 69 yr), which may indicate substantial differences in vegetation that relate more to fires than to grazing.

Air Quality

Emissions

Table 13-1 provides summaries for emissions of carbon monoxide (CO), ammonia (NH_3), nitrogen oxides (NO_x), volatile organic compounds (VOC), particulate matter (PM), and sulfur oxides (SO_x) for 7 counties surrounding Zion National Park. The emissions are relatively low, with the exception of Coconino County in Arizona where the Salt River Project’s Navajo Station is a major point source of SO_x. No information is available to relate these emissions to air quality at Zion National Park, or to apportion Zion's air quality impairment to local vs. regional sources.

Table 13-1. Emissions (tons/day) for counties surrounding Zion National Park (Radian 1994).

County	CO	NH_3	NO_x	VOC	PM	SO_x
Beaver, UT	14.9	0.7	1.7	30.9	142.2	0.3
Garfield, UT	13.7	0.6	1.5	63.0	252.6	0.2
Iron, UT	36.1	0.9	3.7	38.8	190.0	0.9
Kane, UT	14.9	0.3	1.6	44.0	114.4	0.2
Piute, UT	4.6	0.4	0.5	8.9	8.1	0.1
Washington, UT	63.7	0.6	6.5	34.1	189.1	0.9
Coconino, AZ	145.5	3.2	132.8	208.7	658.6	213.2

Air Pollutant Concentrations, Visibility, and Atmospheric Deposition

Almost no information is available for air quality in Zion National Park. Ozone concentrations in 1995 averaged 45 ppb, with a peak weekly concentration of 55 ppb, based on a passive ozone sampler. No information is available on visibility or atmospheric deposition, but regional patterns (such as those at Bryce Canyon and Grand Canyon National Parks) probably bracket the conditions at Zion. Subjective estimates of visibility were undertaken from 1975 to 1977, but discontinued because of lack of quantifiability (Zion National Park 1994). From 1977 through 1982, multi-day impactors were used to collect particulates; these data indicated good air quality, with particulates dominated by silicates. Teleradiometer readings were taken to gauge visibility between 1979 and 1986. Two solar-powered teleradiometers were installed with satellite data transmission, and 5 years of data were collected, but these data were not analyzed because the instrumentation has been discontinued. Transmissometer data represent visibility conditions better. A camera system was installed in the Taylor Creek area of the Kolob Canyon, and removed in 1991.

Sensitivity of plants

No signs of air pollution injury have been reported for vegetation in or near Zion National Park. Only a few of the Park's species have been tested under controlled conditions for sensitivity to pollutants, and none of these tests included genotypes representative of the plants in the Park. Based on the ozone concentrations required to affect very sensitive plants, we expect that current ozone exposures could be high enough to affect some species. Unfortunately, too few data on ozone concentrations are available for a clear characterization of plant exposures. Current levels of ozone are probably too low to affect the conifers, and levels of SO_2 across the Colorado Plateau are far below any demonstrated threshold of sensitivity for any plants. In the absence of empirical evidence of any effects, no substantial problem is likely.

At least 160 species of lichen have been identified in Zion (Zion National Park 1994), and permanent transects have been established in the main Zion Canyon for long-term monitoring. No evidence of any pollution impact has been noted.

Johnson (1994) examined concentrations of zinc, manganese, lead, and cadmium in plants and soils adjacent to roads (within 30 m) and beyond (1000 m). He concluded that zinc, manganese and lead showed higher concentrations near the roads, but that levels were too low to pose a threat to plants, animals, or human health.

Water Quality and Aquatic Organisms

The major water resource in Zion National Park is the Virgin River, cutting through the Zion Narrows. The Virgin River has substantial acid buffering capacity and is unlikely to be affected by acid deposition. The Park also has important freshwater habitats including springs, seeps, creeks and ponds that are relatively undisturbed, and which provide habitat islands for aquatic insects. The southeast side of the Park contains exposed bedrock, with rain-filled depressions called waterpockets, potholes or tinajas. These small water bodies vary in depth from several cm to 5 m, and are usually ephemeral. Gladney et al. (1993) measured ANCs as low as 220 ueq/l in potholes in Utah, indicating a moderately high buffering capacity of some of these water bodies. However, this lower bound of ANC is still not at the concern level for effects of acid deposition; water quality monitoring would be needed to determine the seasonal fluctuations in pothole chemistry. Given the similarity of geology between Zion and Capitol Reef National Park (Chapter 8), we expect that the aquatic systems are similarly well-buffered with respect to acid deposition.

Aquatic Invertebrates

The pothole systems in Zion contain a number of aquatic organisms, including algae, zooplankton, water beetles (Hydrophyllids), backswimmers (Notonectids), dipteran larvae and amphibian larvae. Several unique species of aquatic insects have been recorded in the park in these refugia (Edmunds 1988): *Leptohyphes apache* (Order Ephemeroptera - found in the Virgin River); *Pteronarcys californica* and *Pteronarcys badia* (Order Plecoptera - Rocky Mountain species at their southern extent); *Ochrothrichia zioni* (Order Trichoptera - a rare endemic found in seeps in the park); *Hygrotus virgo* (Order Coleoptera - diving beetle endemic to SW Utah). It is unlikely that these invertebrates will be affected by deposition of acidic materials unless the rainfall pH dropped sufficiently for the pothole pHs to drop below 4.5 (Graham 1991).

Recommendations for Future Monitoring and Research

General recommendations for NPS Class I areas of the Colorado Plateau are presented in Chapter 14, and many of these apply to Zion National Park. Our specific recommendations for this Park include:

- Instituting an air-quality monitoring program that includes at least passive ozone monitoring, and perhaps an NADP site. The IMPROVE network may not need an additional site at Zion to meet the program's regional goals, but the Class I designation of Zion National Park warrants visibility monitoring of some type. A passive ozone monitoring program would not provide estimates of peak concentrations, but may be adequate for estimating cumulative exposures.
- Zion National Park has many unique and important aquatic habitats that serve as refugia for vertebrates and invertebrates. The few measurements taken in pothole systems indicate that ANCs for some approach the level of concern (ANC less than 200 μeq/L). Presumably the water samples were taken during a static period, not following a rain storm or during the snowmelt runoff period. For these reasons we recommend:

    (1) a limited number of pothole systems be selected for periodic water chemistry monitoring to determine the seasonal fluctuations in pH, ANC, anions and cations;

    (2) if reconnaissance monitoring show depressions in pH or ANC or spikes in nitrate or sulfate concentrations, then a regular monitoring program should be put in place; and

(3) if funds are available, dose/response experiments could be conducted on selected pothole systems either in the Park or on adjacent lands (see recommendations for Capitol Reef National Park).

Park Summary

Little information is available for air quality and AQRVs in Zion National Park. We expect that visibility is currently the only AQRV known to be impacted by pollution at Zion, as with the other NPS Class I areas of the Colorado Plateau. Current levels of pollution in southern Utah are probably high enough to produce haze and obscure the important vistas of the Park and surrounding areas. Any increase in aerosols would undoubtedly impair visibility further; substantial reductions in aerosols would be needed to restore pristine conditions at Zion National Park.

Little information has been collected on air pollution effects on the Park's biota. No sign of air pollution impacts on plant or animal species has been reported; ozone concentrations are high enough that some impact is possible for sensitive plants, but SO_2 concentrations on the Colorado Plateau are too low to affect plants.

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